Final Feasibility Study

Lower Fox River and Green Bay, Wisconsin Remedial Investigation and Feasibility Study

Prepared for:

Wisconsin Dept. of Natural Resources

Prepared by: The RETEC Group, Inc.

December 2002

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EXECUTIVE SUMMARY FEASIBILITY STUDY

Lower Fox River and Green Bay

The Feasibility Study (FS) developed and evaluated a range of remedial alternatives for the Lower Fox River and Green Bay (Figure 1) to manage the risk associated with the presence of industrial contaminants discharged to the river. This RI/FS report is consistent with the findings of the National Academy of Sciences Research Council Report entitled *A Risk Management Strategy for PCB-Contaminated Sediments* (NAS, 2001).

Each alternative was compared to nine evaluation criteria including: 1) risk reduction, 2) overall protectiveness of human health and the environment, 3) implementability, 4) short-term effectiveness associated with the remedy action, 5) permanence, 6) reduction in toxicity, mobility and volume, 7) cost, 8) regulatory acceptance, and 9) community acceptance.

The area of concern includes the Lower Fox River extending 63 km (39 mi) from Lake Winnebago to the mouth of Green Bay, and includes the entire 4,150 km^2 (1,600 mi^2) of the bay. Remedial alternatives were developed for the four reaches of the Lower Fox River including: Little Lake Butte des Morts, Appleton to Little Rapids, Little Rapids to De Pere, and De Pere to Green Bay (same as Green Bay Zone 1); as well as the four zones of Green Bay: Zone 2, Zone 3A, Zone 3B, and Zone 4.

The purpose of the FS is to support the selection of a remedy that will eliminate, reduce and/or control short-term and long-term risks. The evaluation in the FS used data developed in the Remedial Investigation (RI), Risk Assessment (RA), and Model Documentation reports to support the screening of alternatives. This screening of alternatives followed EPA's Superfund Guidance document for conducting RI/FS studies under CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act of 1980).

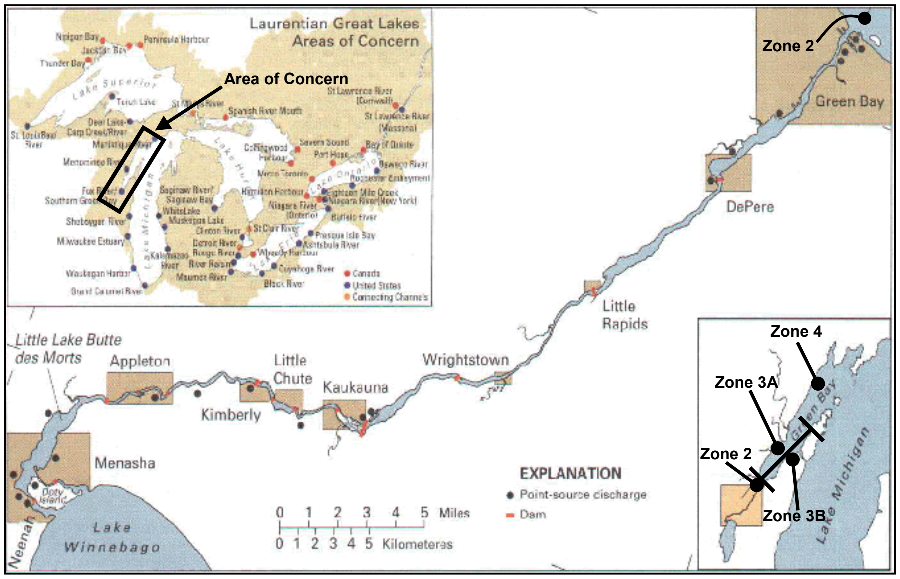

Figure 1 (Fitzgerald & Steuer, 1996)

Site History and PCB Discharges

Between 1954 and 1971, paper mills in the Lower Fox River valley manufactured and recycled carbonless copy paper that contained polychlorinated biphenyls (PCBs), resulting in the release of an estimated 300,000 kg (600,000 pounds) of PCBs to the river. The highest PCB concentrations detected in site sediments were 223 mg/kg in the Little Lake Butte des Morts Reach and 710 mg/kg in the De Pere to Green Bay Reach. WDNR issued PCB consumption advisories in 1976 and 1983 for fish and waterfowl, respectively. The State of Michigan also issued consumption advisories for Green Bay fish in

1977. These advisories are still in effect today.

PCB Distribution, Volume, and Transport

The Remedial Investigation identified the sources of PCBs, the estimated mass, and volume of PCBs in bedded sediments. The RI also estimated the sediment and PCB mass transport rates. Between 65 and 175 kg of PCBs are transported downstream annually from each reach, and 280 kg of PCBs move into Green Bay annually. A significant portion of the PCB loading that occurs in Green Bay is derived from the Lower Fox River. This transport of PCBs also extends to Lake Michigan.

PCBs discharged into the river, in large part today, remain in the bedded sediments of the river and bay. For sediments containing more than 50 μg/kg PCBs, approximately 28,600 kg (63,050 pounds) of PCBs remain in the Lower Fox River (Figure 2) compared to approximately 68,200 kg (150,300 pounds) of PCBs in Green Bay (Figure 3). As stated in the RI report, the PCBs are contained within about 11.8 million cy of sediment in the river. In Green Bay, the PCBs are dispersed in a much greater volume of sediment, approximately 610 million cy.

Risks to Human and Ecological Receptors

The chemicals of concern (COCs) from the Baseline Risk Assessment (RA) included polychlorinated biphenyls (PCBs) (total and selected congeners), mercury, and DDE as the primary compounds of risk to human health and the environment, with PCBs presenting the highest risk. The exposure pathway presenting the greatest level of risk to both human health and ecological receptors is through fish consumption (other than direct risk to benthic invertebrates). Receptors at risk include recreational anglers, high-intake fish consumers, benthic invertebrates, fish, birds, and riverine mammals. PCBs contribute more than 70 percent of the cancer risks found from the consumption of fish and waterfowl.

The risk assessment also derived sediment quality thresholds (SQTs) that were linked to estimated magnitudes of risk to valued receptors. SQTs were developed for over 100 pathways and receptors and arrayed to show the magnitude and protectiveness of potential risks. SQTs themselves are not cleanup criteria, but were used to evaluate levels of PCB risk and help develop FS action levels.

Remedial Action Objectives

The FS reviewed multiple community, state, federal, and private documents to identify common expectations for the Fox River and Green Bay. From this review, five remedial action objectives were formulated. These objectives lay the foundation for remedial expectations for the FS and provide a metrics to measure long-term success. These objectives include:

1. Achieve surface water quality criteria, to the extent practicable;

2. Protect humans who consume aquatic organisms (i.e., remove consumption advisories);

3. Protect ecological receptors (i.e., healthy invertebrate, bird, fish, mammal populations);

4. Reduce transport of PCBs from the river into Green Bay and Lake Michigan; and

5. Minimize contaminant releases during remediation.

These objectives can be further defined into measurable metrics for evaluating long-term remedial success. These measurable expectations were defined by WDNR and EPA as the ability for recreational anglers to consume fish within 10 years following completion of a remedy and 30 years for high-intake fish consumers for human health (RAO 2).

Ecological expectations were defined by WDNR and EPA as the ability to achieve safe ecological thresholds for piscivorous birds and mammals. Although not a specific metric, the FS used 30 years following remedy completion (RAO 3). These expectations assumed several years of active remediation followed by 30 years of recovery, after which the endpoints are measured and compared to protective fish tissue levels.

Other metrics used to measure remedial success include the time to achieve state surface water criteria (RAO 1) and the time for PCB loading rates from the Lower Fox River into Green Bay to equal the combined loading estimates from other tributaries into Green Bay (10 kg/yr PCBs) (RAO 4). For relative comparison between different remedies and action levels, the FS used 30 years following remedy completion to achieve these goals.

Array of Remedial Action Levels

The FS evaluated remedial alternatives, risks, duration, and costs relative to a series of potential sediment cleanup values. These values, termed "remedial action levels," were 125, 250, 500, 1,000, and 5,000 ppb PCBs. For all action levels, it was assumed that different levels of residual risk would remain after remediation. Natural processes would be relied upon to further decrease COC sediment concentrations to protective levels.

Remedial Alternatives

Over 100 technologies were screened during the feasibility study. The remedial alternatives retained for detailed analysis included:

A. No action;

B. Monitored natural recovery (MNR);

C. Dredge and off-site disposal;

D. Dredge and on-site disposal (CDF);

E. Dredge and thermal treatment;

F. *In-situ* containment (capping); and

G. Dredge to confined aquatic disposal (CAD) site.

The alternatives were considered for each of the four river reaches and Green Bay zones (Table 1). All of the active remedies are designed to be completed in 10 years, in combination with natural recovery after remedy completion, with the degree of recovery dependent on the action level selected. Each of these remedial options categories is discussed below. However, final selection of a remedy will be governed by site-specific conditions and expectations.

Monitored Natural Recovery. Natural recovery refers to the processes by which COCs decline over time by biodegradation, dilution, or transport mechanisms. Institutional controls will remain in place to restrict site use until the system has recovered to protective thresholds. Natural recovery of sediments primarily occurs through three processes: burial; mixing and transport; or dechlorination/ biodegradation. The FS determined that all three of these processes occur in the Lower Fox River system, but the success of these processes is continually influenced by ongoing physical processes resulting in limited overall effectiveness in many areas. To evaluate a natural recovery option, it was assumed that the current systems of dams on the river would remain in perpetuity. A long-term monitoring program would be implemented to ensure that sediment, water, and fish tissue PCBs would decline over time.

Removal (Dredging). Removal involves excavation of site sediments using mechanical or hydraulic dredging techniques. Dredging is a common practice for managing impacted sediments but would require careful consideration of: dewatering methods, disposal options, physical obstructions, site access, staging areas, community disturbance, and potential release of contaminants to the environment during implementation. Removal of impacted sediments is a permanent solution and does not require long-term maintenance or access restrictions.

Table 1 Summary of Evaluated Remedial Alternatives by Reach and Zone

Alternative Description	Lower Fox River Reaches				Green Bay Zones			
	Little Lake Butte des Morts	Appleton to Little Rapids	Little Rapids to De Pere	De Pere to Green Bay	Zone 2	Zone 3A	Zone 3B	Zone 4
A No Action	✔	✔	✔	✔	✔	✔	✔	✔
B Monitored Natural Recovery	✔	✔	✔	✔	✔	✔	✔	✔
C Dredge and Off-Site Disposal	✔	✔	✔	✔	✔	✔		
D Dredge to CDF	✔		✔	✔	✔	✔	✔	
E Dredge and Thermal Treat	✔	✔	✔	✔				
F Cap	✔		✔	✔				
G Dredge to CAD					✔	✔	✔	

Treatment. The FS also evaluated treatment and non-treatment options. Retained treatment options included thermal, technologies such as desorption and vitrification, where the resulting product would have the potential for beneficial reuse.

Disposal. Disposal of dredged material can managed in three ways: permanent placement in upland, nearshore, and in-water facilities. It is generally expensive and requires intensive dewatering techniques to adequately prepare sediments for long-term disposal. Several on-site and off-site disposal options were retained in the FS including: nearshore fills, free-standing confined disposal facilities (CDFs), submerged aquatic disposal sites (CADs), and upland landfills where impacted sediments are placed in containment structures designed to isolate and contain contaminants over the long-term.

Containment (Capping). Containment involves the physical isolation and immobilization of chemicals in sediments. Capping is a common method for containing impacted sediments in-place. It would require long-term restrictions on site access and land use rights, in addition to long-term monitoring and maintenance to ensure integrity of the capping structure. The capping alternative would require careful consideration of site conditions, navigational channels, river currents, vessel propeller wash, water depths, and ice scour as well as other factors that may limit the installation and subsequent permanence of cap placement.

Comparative Analysis

Each alternative was compared to the nine evaluation criteria defined above for each river reach and Green Bay zone. Risk reduction and overall protectiveness are discussed below. Implementablity and effectiveness were determined as feasible for each retained alternative based on availability, previous experience, and performance-based results. Reduction of toxicity, mobility, and volume is related to cost. Both are dependent on the action level selected. Thermal treatment is the only alternative that permanently reduces PCB volume and mass. Relative costs are discussed below, and community acceptance of the retained alternatives will be evaluated during public comment periods and outreach programs.

Risk Reduction

The ability of the seven remedial alternatives to achieve the FS expectations were quantified by relative risk reduction over time using hydrodynamic and bioaccumulation models over a projected 100-year time frame. These models predicted the number of years required to reach protective thresholds for human health and the environment (e.g., number of years required to remove fish consumption advisories). The projected number of years required to consistently meet protective water quality, human health, ecological health, and PCB transport thresholds following remediation (the RAOs) were compared to different action levels and costs for each alternative. Results are presented on Figures 2 and 3. A comparative analysis of action levels that meet protective levels between the different river reaches is presented on Figures 4 and 5.

Water Quality. The state surface water quality criteria for protection of human health are not met for any combination of remedial scenario and action level in the river. Only the wildlife criteria (0.12 ng/L) is met in 16 years after remediation for the 125 ppb action level, increasing to 69 years for the 1,000 ppb action level.

Human Health. As shown on Figures 4 and 5, in order to remove recreational fish consumption advisories within 10 years following remediation (WDNR's expectation), remedies implemented to the 1,000 ppb PCB action level for surface sediments would be required for most of the river reaches. Action levels ranging from 250 ppb to 1,000 ppb would be required to remove high-intake consumer advisories within 30 years following remediation depending upon the specific reach of the river. For Green Bay, none of the remedies are projected to achieve the protective human health values. These model projections account for dynamic physical properties of the system including water velocity, water depth, currents, flooding, natural deposition, scour events, and storm events.

Ecological Health. To meet the protective ecological thresholds in the expected 30-year time frame following remedy completion, an estimated minimum action level of 1,000 ppb would be required in the Little Lake Butte de Morts and Appleton to Little Rapids reaches. A minimum action level of 250 ppb would be required in the Little Rapids to De Pere and De Pere to Green Bay reaches. The No Action alternative (passive remediation) would require greater than 100 years to meet protective ecological thresholds in the Lower Fox River (Figure 4). In Green Bay, none of the remedies will meet protective ecological thresholds in 100 years based on projected fish tissue concentrations, regardless of the action taken in the Lower Fox River (Figure 5).

PCB Transport. One of the long-term goals of the project is to reduce the transport and load of PCBs to Green Bay, and subsequent movement to Lake Michigan. The total annual average loading rates of PCBs to Green Bay from all tributaries combined (without the Fox River) is currently 10 kg/year PCBs. The Fox River fate and transport models were used to predict the number of years required to reduce the PCB loads from the Fox River into Green Bay over time after remedy completion. At the expected 30-year time frame following remedy completion, the projected loading rates from the Fox River were compared to the loading rates of all other Green Bay tributaries combined. These levels could be considered "background" levels.

Remedies to at least the 5,000 ppb action level would be required in the De Pere to Green Bay Reach to meet projected expectations. PCB load expectations for these two action levels would require 24 years to meet tributary levels. At the 1,000 ppb action level, the target level is achieved in 4 years following remediation. The model predications for PCB loading rates from the mouth of the Fox River (De Pere to Green Bay Reach) takes into consideration the cumulative PCB loads from the upper reaches; therefore, only the last reach was evaluated in the FS.

It is important to note there is uncertainty associated with these projected estimations of risk reduction and duration to meet protective thresholds. The model projections were calibrated over a finite time interval and projected out to 100 years based on the trends observed during the short calibration period. The projected risk reductions/durations cannot predict the actual number of years to reach protective thresholds with considerable precision. However, the strength of these models is the relative risk reduction estimates for comparing between different action levels and remedial alternatives. More information on the models may be found in the Lower Fox River and Green Bay Model Documentation Report.

FS Costs

Total remediation costs were estimated for each remediation alternative and each PCB action level (±30 percent), as presented on Figures 2 and 3. In the Lower Fox River, the costs for active remediation (Alternatives C through F) range from approximately $38,300,000 to $769,100,000 per river reach (Table 2). In Green Bay, the costs for active remediation (Alternatives C, D, and G) range from approximately $11,000,000 to $1,155,100,000 (Table 3). Costs include land acquisition, mobilization, permits, facility construction, dredging and dewatering, disposal, materials, labor oversight, public outreach, site restoration efforts, operation and maintenance costs, in addition to long-term monitoring efforts for 30 years following remediation.

The cost for passive remediation, or monitored natural recovery (Alternative B), is approximately $9,900,000 per reach/zone over a 30-year period. MNR costs include maintenance of institutional controls along with sediment, surface water, bird and fish tissue sampling, and invertebrate sampling events conducted every 5 years for 30 years. Costs are calculated as net present worth costs.

The largest variability in costs are observed between different action levels. Remediation costs are directly proportional to sediment volumes; therefore, as the action level decreases (becomes more protective), the sediment volume requiring removal increases and the cost increases. For example, the cost to place an *in-situ* sand cap (Alternative F) in the Little Lake Butte des Morts Reach will cost approximately $145,200,000 at the 125 ppb action level but only $66,200,000 at the 5,000 ppb action level.

When comparing costs between different alternatives in the Lower Fox River, the active remedy costs are 3 to 78 times higher than the passive remedy costs. Among the active remedies, the Dredge and Treat Alternative is the least-cost remedy (ranging from a 3-fold to 40-fold increase over the MNR Alternative). The Capping Alternative and Dredge to CDF Alternative are generally the medium-cost remedies (ranging from a 4-fold to 60-fold increase over the MNR Alternative). The Dredge and Off-site Disposal Alternative is the highest-cost remedy (ranging from a 4-fold to 78-fold increase over the MNR Alternative). In Green Bay, the active remedy costs are similar when compared within a single action level.

Further Information

Remedy selection for the Lower Fox River and Green Bay will be based on the information contained within the RI, RA and FS, as well as numerous opportunities for input by the public and interested parties. For further information regarding the Lower Fox River RI, FS, RA, or MDR documents, please contact:

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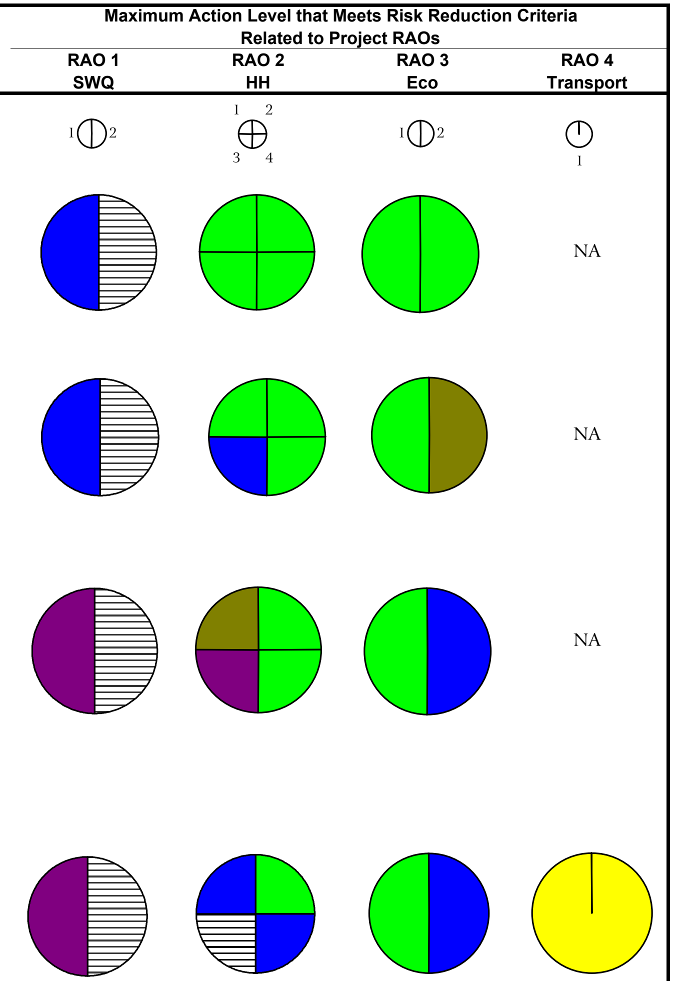
Figure 2 Lower Fox River Summary of Remedial Action Levels and Projects Risk Reduction by Reach

Lower Fox River Reaches	Remediation Alternative	PCB Action Level (ppb) 125	250	500	1,000	5,000	RAO 4 Transport
Little Lake Butte des Morts	Impacted Volume (cy)	1,689,173	1,322,818	1,023,621	784,192	281,689	NA
	PCB Mass (kg)	1,838	1,814	1,782	1,715	1,329	
	Remedial Cost (in 1,000s $)						
	A/B: No Action	$9,900	$9,900	$9,900	$9,900	$9,900	
	C1: Dredge, Off-site Disp. (Pass. Dewater)	$231,500	$185,600	$147,800	$116,700	$48,500	
	C2: Dredge, Off-site Disp. (Mech. Dewater)	$126,200	$102,500	$82,800	$66,200	$28,300	
	D: Dredge to CDF, Off-site TSCA Disp.	$116,000	$110,300	$105,100	$68,000	$54,500	
	E: Dredge and Thermal Treatment	$117,200	$96,000	$78,500	$63,600	$29,300	
	F: Cap and Dredge to CDF	$145,200	$138,600	$99,300	$90,500	$66,200	
Appleton to Little Rapids	Impacted Volume (cy)	182,450	80,611	56,998	46,178	20,148	NA
	PCB Mass (kg)	106	99	95	92	67	
	Remedial Cost (in 1,000s $)						
	A/B: No Action	$9,900	$9,900	$9,900	$9,900	$9,900	
	C: Dredge, Off-site Disp.	$38,300	$25,000	$21,700	$20,100	$16,500	
	E: Dredge and Thermal Treatment	$26,200	$19,700	$17,900	$17,100	$15,200	
Little Rapids to De Pere	Impacted Volume (cy)	1,483,156	1,171,585	776,791	586,788	186,348	NA
	PCB Mass (kg)	1,210	1,192	1,157	1,111	798	
	Remedial Cost (in 1,000s $)						
	A/B: No Action	$9,900	$9,900	$9,900	$9,900	$9,900	
	C1: Dredge to NR 500 Facility (Pass. Dewater)	$224,200	$180,700	$124,200	$95,100	$38,100	
	C2A: Dredge to Comb. Dewater/Disp. Facility	$72,300	$63,200	$51,400	$43,900	$32,400	
	C2B: Dredge to Sep. Dewater/Disp. Facilities	$179,800	$152,800	$118,300	$99,900	$65,300	
	C3: Dredge to NR 500 Facility (Mech. Dewater)	$161,700	$130,800	$90,300	$69,100	$28,400	
	D: Dredge to CDF, Off-site TSCA Disp.	$72,300	$66,800	$58,400	$52,500	$44,400	
	E: Dredge and Thermal Treatment	$142,700	$123,800	$99,500	$86,200	$61,900	
	F: Cap and Dredge to CDF	$143,700	$114,300	$87,800	$62,900	$34,700	
De Pere to Green Bay	Impacted Volume (cy)	6,868,500	6,449,065	6,169,458	5,879,529	4,517,391	
	TSCA Volume (cy)	240,778	240,778	240,778	240,778	240,778	
	PCB Mass (kg)	26,620	26,581	26,528	26,433	24,950	
	Remedial Cost (in 1,000s $)						
	A/B: No Action	$9,900	$9,900	$9,900	$9,900	$9,900	
	C1: Dredge to NR 500 Facility (Pass. Dewater)	$769,100	$723,100	$692,300	$660,600	$511,100	
	C2A: Dredge to Comb. Dewater/Disp. Facility	$196,000	$186,900	$180,400	$173,500	$138,700	
	C2B: Dredge to Sep. Dewater/Disp. Facilities	$564,500	$534,100	$513,500	$491,800	$388,000	
	C3: Dredge to NR 500 Facility (Mech. Dewater)	$595,200	$561,000	$537,800	$513,500	$397,200	
	D: Dredge to CDF, Off-site TSCA Disp.	$611,800	$566,400	$536,200	$505,100	$360,700	
	E: Dredge and Thermal Treatment	$404,500	$384,000	$370,000	$355,100	$283,300	
	F: Cap and Dredge to CDF	$432,600	$403,900	$381,900	$357,100	$234,400	

Maximum Action Level that Meets Risk Reduction Criteria Related to Project RAOs



Notes:

Threshold criteria used to evaluate risk reduction:

RAO 1: 1 = Wildlife Criteria 30-year, 2 = Human Surface Water Drinking Criteria 30-year.
RAO 2: 1 = High-intake Fish Consumer Cancer 30-year, 2 = High-intake Fish Consumer Noncancer 30-year,
3 = Recreational Angler Cancer 10-year, 4 = Recreational Angler Noncancer 10-year.
RAO 3: 1 = Carnivorous Bird Deformity NOAEC 30-year, 2 = Piscivorous Mammal NOAEC 30-year.
RAO 4: 1 = Tributary Load to Reach Green Bay Level 30-year.
NA - Not applicable.

Action Level (ppb) that Consistently Meets Criteria after 10 or 30 Years of Recovery after Remediation Completion

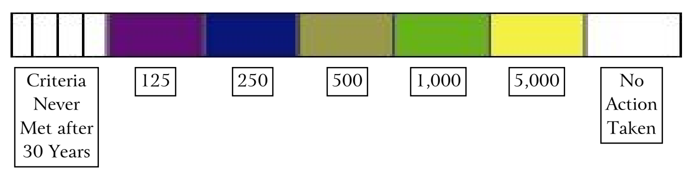
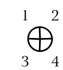
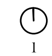
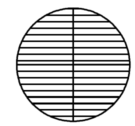
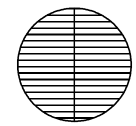
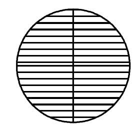
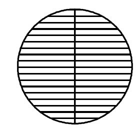
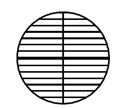
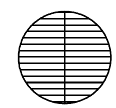
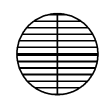
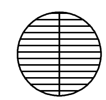


Figure 3 Green Bay Summary of Remedial Action Levels and Projected Risk Reduction by Zone

Green Bay Zone	Remediation Alternative	Action Level (ppb) 125	250	500	1,000	5,000	Maximum Action Level that Meets Risk Reduction Criteria Related to Project RAOs: RAO 1 SWQ	RAO 2 HH	RAO 3 Eco	RAO 4 Transport
										
Green Bay Zone 2	Impacted Volume (cy)	NE	NE	29,748,004	29,322,254	4,070,170				
	PCB Mass (kg)	NE	NE	29,896	29,768	6,113				
	Remedial Cost (in 1,000s $)									
	A/B: No Action	NA	NA	$9,900	$9,900	$9,900	NE			NA
	C: Dredge, Off-site Disp.	NA	NA	NA	NA	$507,200				
	D: Dredge to CDF, Off-site TSCA Disp.	NA	NA	$824,700	$814,100	$166,500				
	G: Dredge to CAD	NA	NA	$707,400	$697,800	$124,000				
Green Bay Zone 3A	Impacted Volume (cy)	NE	NE	16,328,102	14,410	NE				
	PCB Mass (kg)	NE	NE	2,156	2	NE				
	Remedial Cost (in 1,000s $)									
	A/B: No Action	NA	NA	$9,900	$9,900	NA	NE			NA
	C: Dredge, Off-site Disp.	NA	NA	NA	$11,000	NA				
	D: Dredge to CDF, Off-site TSCA Disp.	NA	NA	$474,300	NA	NA				
	G: Dredge to CAD	NA	NA	$389,100	NA	NA				
Green Bay Zone 3B	Impacted Volume (cy)	NE	NE	43,625,096	NE	NE				
	PCB Mass (kg)	NE	NE	4,818	NE	NE				
	Remedial Cost (in 1,000s $)						NE			NA
	A/B: No Action	NA	NA	$9,900	NA	NA				
	D: Dredge to CDF, Off-site TSCA Disp.	NA	NA	$1,155,100	NA	NA				
	G: Dredge to CAD	NA	NA	$1,010,900	NA	NA				
Green Bay Zone 4	Impacted Volume (cy)	NE	NE	0	NE	NE				
	PCB Mass (kg)	NE	NE	0	NE	NE				
	Remedial Cost (in 1,000s $)						NE			NA
	A/B: No Action	NA	NA	$9,900	NA	NA				

Notes:

Threshold criteria used to evaluate risk reduction:

RAO 1: 1 = Wildlife Criteria 30-year, 2 = Human Surface Water Drinking Criteria 30-year.
RAO 2: 1 = High-intake Fish Consumer Cancer 30-year, 2 = High-intake Fish Consumer Noncancer 30-year, 3 = Recreational Angler Cancer 10-year, 4 = Recreational Angler Noncancer 10-year.
RAO 3: 1 = Carnivorous Bird Deformity NOAEC 30-year, 2 = Piscivorous Mammal NOAEC 30-year.
RAO 4: 1 = Tributary Load to Reach Green Bay Level 30-year.
NA - Not applicable.
NE - Not evaluated.

Action Level (ppb) that Consistently Meets Criteria after 10 or 30 Years of Recovery after Remediation Completion

Criteria Never Met after 30 Years | 125 | 250 | 500 | 1,000 | 5,000 | No Action Taken

Figure 4 Comparison of Human Health Protectiveness - All Reaches

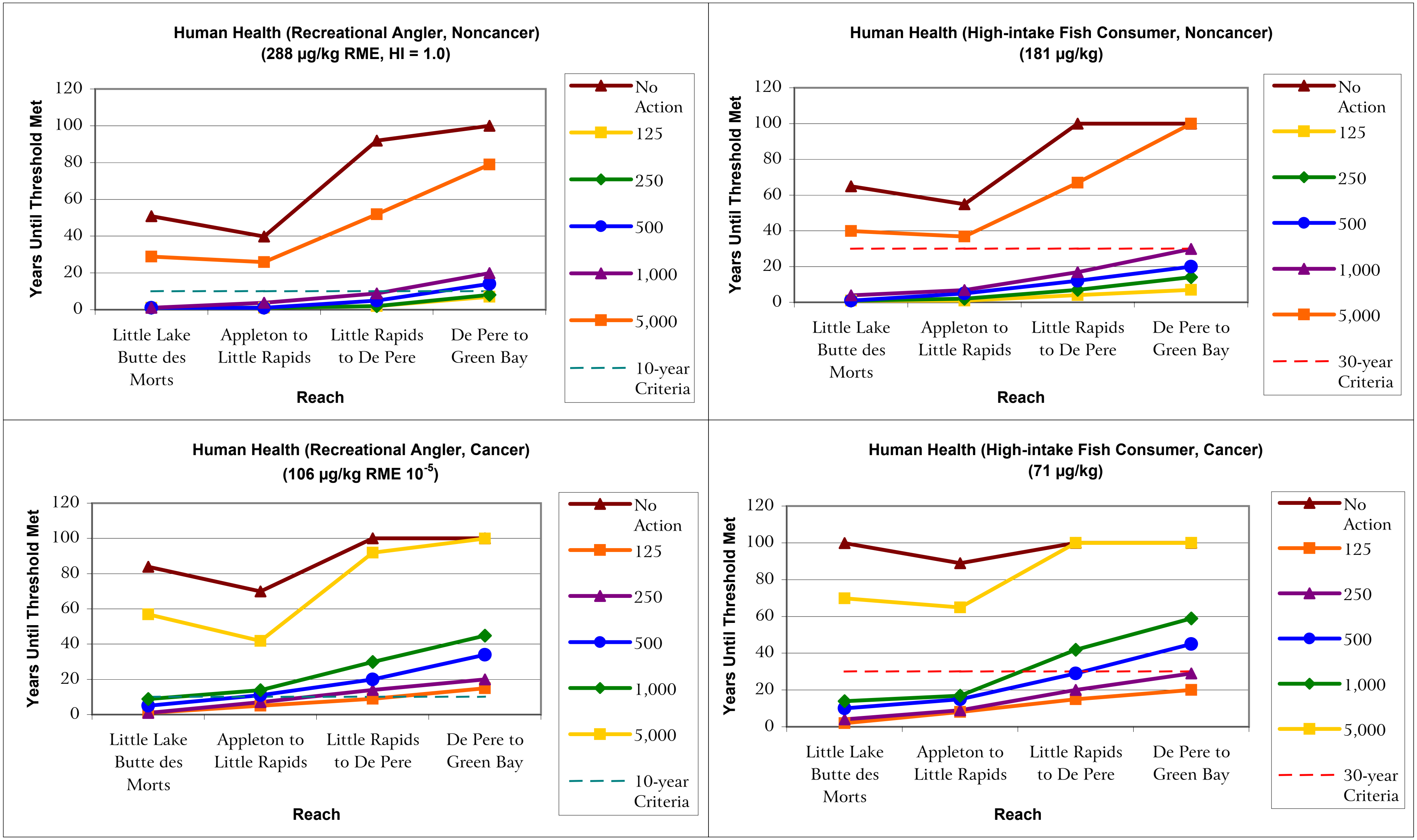
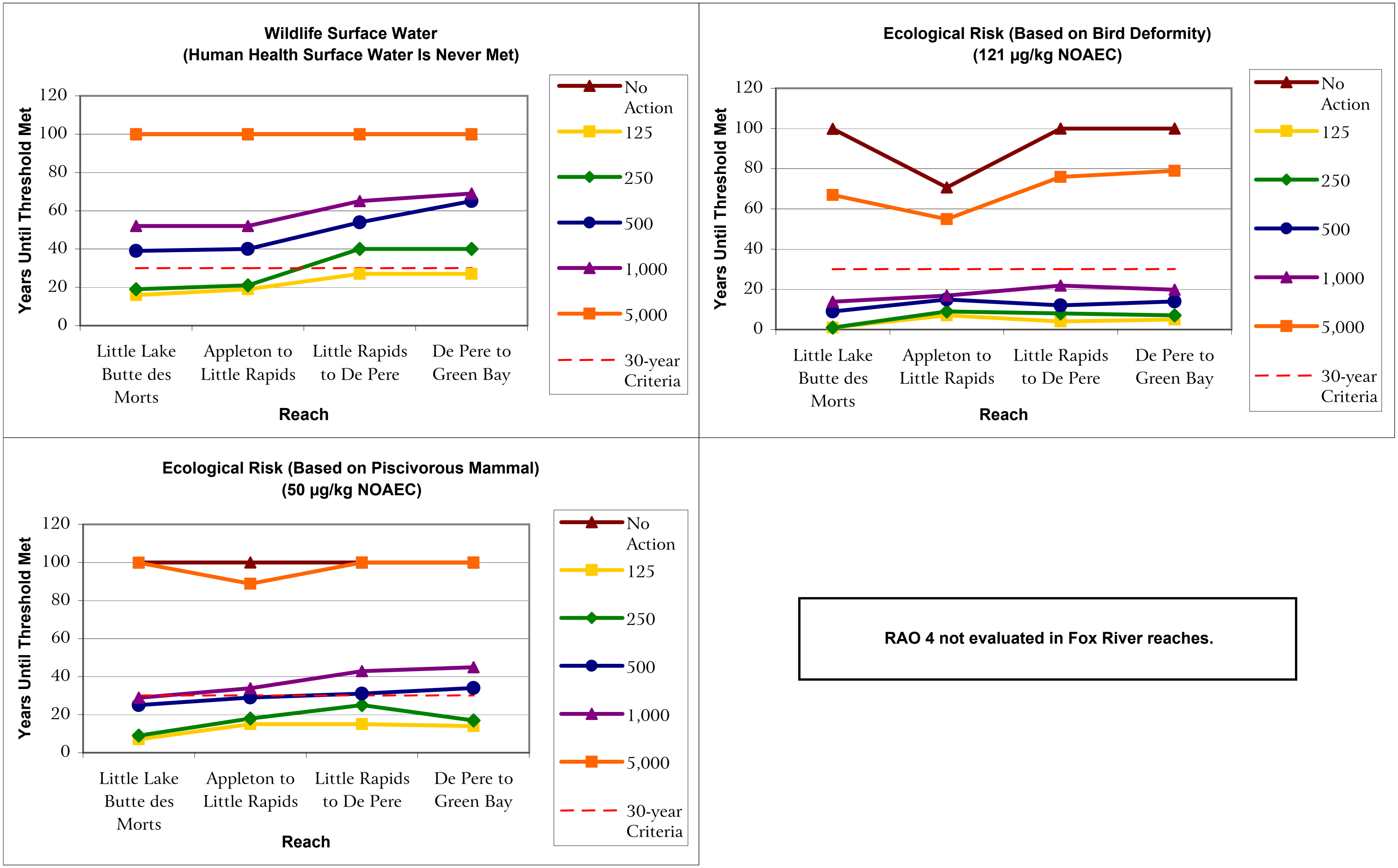


Figure 5 Comparison of Protection - All Reaches



RAO 4 not evaluated in Fox River reaches.

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Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

List of Figures

List of Figures

List of Figures

List of Figures

List of Figures

List of Figures

List of Tables

List of Tables

List of Tables

List of Tables

List of Plates

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List of Appendices

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List of Acronyms

2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin
2,3,7,8-TCDF	2,3,7,8-tetrachlorodibenzo-*p*-furan
˚C	degrees centigrade
˚F	degrees Fahrenheit
μg/kg	micrograms per kilogram
μg/L	micrograms per liter
AOC	Area of Concern
APEG	potassium polyethylene glycol
ARAR	Applicable or Relevant and Appropriate Requirement
ARCS	Assessment and Remediation of Contaminated Sediments
ASRA	Alternative-specific Risk Assessment
ATP	anaerobic thermal processor
AVM	acoustic velocity meter
BBL	Blasland, Bouck, and Lee
BCD	base catalyzed decomposition
Be-7	beryllium-7
BLRA	Baseline Human Health and Ecological Risk Assessment
BOD	SMU 56/57 Basis of Design Report
CAD	confined aquatic disposal
CAMP	Comprehensive Analysis of Mitigation Pathways
CDF	confined disposal facility
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980 (Superfund Statute)
cf	cubic feet
CFR	Code of Federal Regulations
cfs	cubic feet per second
CH	highly plastic clay
cm	centimeter
cm/s	centimeters per second
cm/yr	centimeters per year
COC	chemical of concern
COPC	chemical of potential concern
Cs-137	cesium 137
CTE	central tendency exposure
CTF	confined treatment facility
CWA	Clean Water Act
cy	cubic yard
cy/hr	cubic yards per hour
DAMOS	Disposal Area Monitoring System

List of Acronyms

DDD	4,4'-dichlorodiphenyl dichloroethane (includes isomers o,p'-DDD and p,p'-DDD)
DDE	4,4'-dichlorodiphenyl dichloroethylene (includes isomers o,p'-DDE and p,p'-DDE)
DDT	4,4'-dichlorodiphenyl trichloroethylene (includes isomers o,p'-DDT and p,p'-DDT)
DGPS	differential global positioning system
DM	data management
DO	dissolved oxygen
DOD	United States Department of Defense
DOER	Dredging Operations and Environmental Research Program
DRE	destruction removal efficiency
EPA	United States Environmental Protection Agency
ESRI	Environmental Systems Research Institute
EWI	EWI Engineering Associated, Inc.
FEMA	Federal Emergency Management Agency
FRDB	Fox River Database
FRFood	Lower Fox River Food Web Model
FRG	Fox River Group
FRM	Fox River Model
FS	Feasibility Study
ft	foot or feet
ft^2	square feet
ft^3	cubic feet
ft/ft	feet per foot
ft/s	feet per second
g	gram
g/cc	grams per cubic centimeter
GAC	granular activated carbon
GAS	Graef, Anhalt, Schloemer and Associates, Inc.
GBFood	Green Bay Food Web Model
GBHYDRO	Green Bay Hydrodynamics Model
GBMBS	Green Bay Mass Balance Study
GBSED	Green Bay Sediment Transport Model
GBTOX	Green Bay Toxics Model
GBTOXe	Enhanced Green Bay Toxics Model
g/cm^3	grams per cubic centimeter
GLNPO	Great Lakes National Program Office (EPA)
GLSFA	Great Lakes Sport Fish Advisory Task Force

List of Acronyms

GLWQI	Great Lakes Water Quality Initiative
GM	General Motors
gpm	gallons per minute
GRA	general response action
HAZMAT	hazardous materials
HDPE	high-density polyethylene
HI	hazard index
HQ	hazard quotient
HTTD	high-temperature thermal desorption
IDA	inter-deposit area
IGLD	International Great Lakes Datum
IJC	International Joint Commission
K_d	log soil/water partition coefficient
kg	kilogram
kg/yr	kilograms per year
km	kilometer
km^2	square kilometer
K_{oc}	organic carbon partitioning coefficient
K_{ow}	octanol water partitioning coefficient
L	liter
LCL	Lower Confidence Limit
LFR	Lower Fox River
LLBdM	Little Lake Butte des Morts
LOAEC	Lowest Observed Adverse Effect Concentration
LTA	long-term average
LTMP	Long-term Monitoring Plan
m	meter
m^2	square meter
m^3	cubic meter
m/s	meters per second
m^3/s	cubic meters per second
mg/cm^2	milligrams per square centimeter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MH	high-compressibility silt
mi^2	square mile
m/km	meters per kilometer
MNR	monitored natural recovery
Mpa	mega Pascal

List of Acronyms

MSL	mean sea level
MT	metric tons
MT/yr	metric tons per year
NAAQS	National Primary and Secondary Ambient Air Quality Standards
NAS	National Academy of Sciences
NCP	National Contingency Plan
NESHAPS	National Emissions Standards for Hazardous Air Pollutants
ng/kg	nanograms per kilogram
ng/L	nanograms per liter
NGVD29	National Geodetic Vertical Datum 1929
NOAA	National Oceanic and Atmospheric Administration
NOAEC	No Observed Adverse Effect Concentration
NPDES	National Pollutant Discharge Elimination System
NR	Natural Recovery
NRC	National Research Council
NRDA	Natural Resources Damage Estimate
O&M	operation and maintenance
OBAI	Ogden-Beeman and Associates
OSHA	Occupational Safety and Health Administration
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDD	dibenzo-*p*-dioxin
PCH	planar chlorinated hydrocarbon
PCP	pentachlorophenol
POTW	publicly-owned treatment works
PPE	personal protective equipment
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
PRP	potentially responsible party
psi	pounds per square inch
PSNS	Puget Sound Naval Shipyard
$Q_{7,10}$	7-day average low stream flow with a 10-year frequency
RA	Risk Assessment
RAO	Remedial Action Objective
RBFC	risk-based fish concentration
RCRA	Resource Conservation and Recovery Act
RETEC	Remediation Technologies, Inc.
RI	Remedial Investigation

List of Acronyms

RI/FS	Remedial Investigation and Feasibility Study
RME	reasonable maximum exposure
ROD	Record of Decision
rpm	revolutions per minute
SCS	Soil Conservation Service
SEDTEC	Sediment Technologies CD-ROM by Environment Canada
SFV	stream flow velocity
SITE	Superfund Innovative Technology Evaluation
SLRA	Screening Level Risk Assessment
SMU	Sediment Management Unit
SQT	sediment quality threshold
SRD	sediment remediation demonstration
SVE	soil vapor extraction
SVOC	semivolatile organic compound
SWAC	surface-weighted average concentration
TBC	information "to be considered"
TEL	threshold effect concentration
TEQ	toxic equivalency factor
TMDL	total maximum daily loads
TOC	total organic carbon
TSCA	Toxic Substances Control Act
TSS	total suspended solids
TWA	time-weighted average
UCL	Upper Confidence Limit
UFR	Upper Fox River
UFR/LFR	Upper Fox River/Lower Fox River Sediment Transport Model
UP	Michigan's Upper Peninsula
U.S.	United States of America
USACE	United States Army Corps of Engineers
U.S.C.	United States Code
U.S.C.A.	United States Code, Amended
USCS	Unified Soil Classification System
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UV	ultraviolet
VOC	volatile organic compound
v/v	volume per volume
WAC	Wisconsin Administrative Code
WASP4	Water Quality Analysis Simulation Program Version 4

List of Acronyms

WDNR	Wisconsin Department of Natural Resources
wLFR	whole Lower Fox River
wLFRM	Whole Lower Fox River Fate and Transport Model
WPDES	Wisconsin Pollutant Discharge Elimination System
WQC	water quality criteria
WSEV	Window Subsampling Empirical Variance
w/w	weight per weight
WY	water year
yr	year